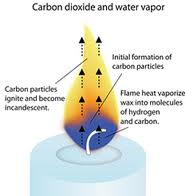
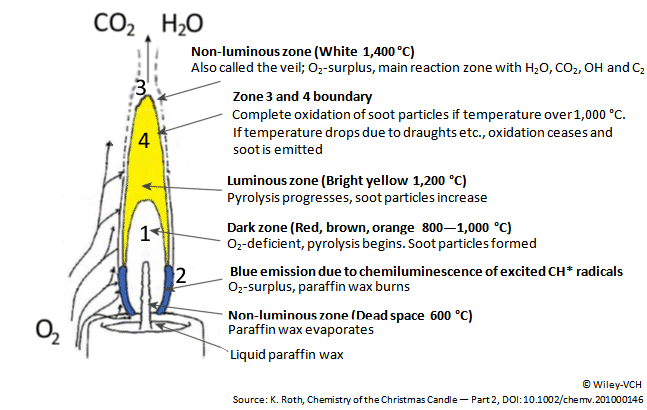
**Week 4 expert group 1, member 3, activity 2**

Kathy Kypr

**What happens when a candle burns?**  
When a candle burns, it’s not the wick or the melted wax that’s burning. It’s the vaporized wax that burns. Wax goes from solid to liquid to vapor just like most things do when you heat them. And it’s only the vapor part of the wax that burns. When you blow out the flame, there’s still enough wax vapor around the candle to light the vapor trail from 5 or even 10 cm away – try it!

The physical change occurs when the heat displaces the bonds that solidify the wax. Upon cooling, the wax is able to form the bond again. The chemical changes are much more complex. The first change is that the heat (fire) consumes the oxygen and fuels the flame. This then leads to the production and emission of carbon dioxide from the flame. As a by-product of the wick burning, you will then achieve soot as another physical and chemical change. The soot is a by-product of the wick (chemical) and leaves a solid product as the emit (physical).

The rate of heat release depends on the rate of the chemical reaction between the (vaporized) hydrocarbon and the oxygen in the air. The rate of the chemical reaction depends on the concentration of the two species (oxygen and hydrocarbon), among other things. The concentration of oxygen is greatest on the outer edge of the flame since the source of the oxygen is the atmosphere. The concentration of the hydrocarbon is greatest near the wick but at that point there is almost no oxygen (because it is used up reacting with the hydrocarbon near the outer edges of the flame). As a result, the hydrocarbon doesn't burn well in the center of the flame and is hottest near the edges.   
  
Combustion chemistry is quite complicated. Different reactions are occurring in the different regions of a flame. A flame will burn hotter and faster in pure oxygen than in air, because the flame's heat is not carried away by unreactive nitrogen molecules.   
  
If you look at a candle flame, you will see that near the wick, the flame is nearly invisible, and that a yellow luminous zone surrounds this. Near the wick, the paraffin vapors are breaking down, releasing hydrogen and creating long, unsaturated carbon chains. This pyrolysis process is actually endothermic (heat-consuming), and can only occur because of the heat supplied by the reactions occurring in the luminous region. Here, the carbon chains have gotten so large that they are actually tiny particles of soot. These soot particles burn just like charcoal, and the yellow light released by the candle flame is from these hot, burning soot particles, just as the light from a light bulb is from the hot filament. If there is enough oxygen (or not too much paraffin vapor being created at the wick), the soot particles all burn up in the flame, and the candle releases only heat, light, water, and carbon dioxide. If the flame is too "rich," unburned soot particles can escape from the flame. (You can see that soot is present in the yellow region of the flame by placing a metal knife blade or wire into the flame: the part in the yellow zone, and only in the yellow zone, will become covered with soot.)   
  
The hottest part of the candle flame is the top, because that's where all the hot product gases go.   
  
The faint blue glow at the bottom of the flame is from a short-lived molecule formed in the flame: diatomic carbon, C2.

**Fantastic clip on ‘Why candles burn’.**

<http://www.youtube.com/watch?v=6Dn0CW-KbvY>

**Cars and pollution**

In a similar way that a candle uses combustion energy to burn the paraffin, cars use combustion energy to burn petroleum.

The purpose of a car engine is to convert petroleum into motion so that your car can move. Currently the easiest way to create motion from gasoline is to burn the gasoline inside an engine. Therefore, a car engine is an **internal combustion engine** (combustion takes place internally).

Two things to note:

* There are different kinds of internal combustion engines. [Diesel engines](http://auto.howstuffworks.com/diesel.htm) are one form and [gas turbine engines](http://science.howstuffworks.com/transport/flight/modern/turbine.htm) are another. See also the articles on [HEMI engines](http://auto.howstuffworks.com/hemi.htm), [rotary engines](http://auto.howstuffworks.com/rotary-engine.htm) and [two-stroke engines](http://science.howstuffworks.com/transport/engines-equipment/two-stroke.htm). Each has its own advantages and disadvantages.
* There is such a thing as an **external** combustion engine. A [steam engine](http://science.howstuffworks.com/transport/engines-equipment/steam.htm) in old-fashioned trains and steam boats is the best example of an external combustion engine. The fuel (coal, wood, oil, whatever) in a steam engine burns outside the engine to create steam, and the steam creates motion inside the engine. Internal combustion is a lot more efficient (takes less fuel per mile) than external combustion, plus an internal combustion engine is a lot smaller than an equivalent external combustion engine. This explains why we don't see any cars from Ford and GM using steam engines.

**What are Combustion Pollutants?**

Combustion pollutants are gases or particles that come from the burning of fuels:

* Natural or LP (liquefied petroleum) gas
* Wood
* Oil
* Kerosene
* Coal

Combustion pollutants are sometimes called combustion by-products because they are produced by the burning of all fossil fuels.

**Clip on ‘understanding of burning to explain how cars pollute the air’.**

<http://www.youtube.com/watch?v=jw3ZRmKUKyA>

**How cars pollute the air**

<http://www.youtube.com/watch?v=MoGCU8q7zFo>

***Information sources***

Newton – US Department of Energy explanation.

<http://www.newton.dep.anl.gov/askasci/chem99/chem99454.htm>

Experimentals

<http://www.abc.net.au/science/experimentals/experiments/episode24_1.htm>

How stuff works

<http://www.howstuffworks.com/engine.htm>